The Pharma Innovation Journal 2023; 12(6): 5004-5013

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 5004-5013

www.thepharmajournal.com
Received: 04-04-2023
Accepted: 14-05-2023

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# Effect of phosphorus solubilizing bacteria (PSB) and sulphur on productivity and profitability of mustard (*Brassica juncea* L.) in central plain zone of Uttar Pradesh

**Seema Patel, Naveen Kumar Maurya, Shivam Kumar, Ravikesh Kumar Pal and Deepa Singh**

**Abstract**
Rapeseed and mustard is most important group of oilseed crops grown under the wide range of agro-climatic conditions in India. These crops are economically important for local and international market. The edible oil content in rapeseed and mustard crop, range from 30-48%. This also used as main cooking oil in northern India. All parameters *viz.,* plant population, plant hight (cm), number of branches per plant, number of primary and secondary branches per plant, leaf area index, harvest index in mustard crop were recorded maximum with the application of the 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB ($T_7$) than other treatments. Similarly, the application of treatment $T_7$ resulted in to significantly increases dry matter accumulation per plant, biological yield and test weight in mustard crop than other treatments at all the stages. The treatments $T_7$ were recoded maximum number siliques per plant, maximum number of grains per silique, maximum length of silique than other treatments. The maximum stover yield, seed yield, oil content and oil yield of mustard crop were also recorded in treatment $T_7$ which was more than other treatments. The treatments $T_7$ (100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB) resulted in to similar N, P and K content and uptake by seed mustard crop but significantly more than other treatments. The effect of PSB and sulphur on mustard was found beneficial with the application of 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB inoculation gave the maximum net return and benefit cost ratio.

**Keywords:** Phosphorus solubilizing bacteria, sulphur, productivity & profitability of *Brassica juncea* L.

## 1. Introduction
Rapeseed and mustard is most important group of oilseed crops grown under the wide range of agro-climatic conditions in India. These crops are economically important for local and international market. The edible oil content in rapeseed and mustard crop, range from 30-48%. This also used as main cooking oil in northern India. Rapeseed and mustard comprise Toria (*Brassica rapa* L. and *Brassica compestris* L.), Taramira (*Eruca sativa* Mill), Raya (*Brassica juncea* L.), Gobhi Sarson (*Brassica napus* L.) and African Sarson (*Brassica carinata* Braun) belonging to the family Cruciferae. Rapeseed & Mustard oilseed crop are the world's third most important sources of vegetable edible oil. In the world, the rapeseed and mustard crops are also cultivated in 53 countries which are spreading over the six continents across the globe covered area. Mustard is the most important oilseed crops of rapeseed mustard group and it is the most dominating *Rabi* oilseed crop of Northern U.P. Mustard oil is the prominent edible oil crop in North India and is extensively grown traditionally as a pure crop as well as intercrop (or mixed crop) in marginal and sub marginal soils in the eastern, northern and north-western states of India. Cool moist climate of winter months is the major factor for the luxuriant growth and productivity of mustard in these states. In relatively warmer winter climate, in the Central and Southern states, mustard is grown only as a mixed crop for seed being used for condiment purposes of productivity of mustard is highest (1559 kg ha$^{-1}$) in the state of Haryana and lowest (524 kg ha$^{-1}$) in Assam with an overall national average being in the range 900-1150 kg ha$^{-1}$ which is the actually harvested yield and is commonly a fraction of the attainable yield of 2500-3000 kg ha$^{-1}$ because of unmanaged or inadequately managed major diseases and pests at different phenotypic stages of the crop. In UP, productivity is about 889.00 kg ha$^{-1}$. In India, a part of overall area which covered under mustard crop has improved by 0.934 million ha to 7.05 million hectares while the production is expected to be increase only by 1.23 million tonnes to 7.97 million tonnes.

The standard productivity of rapeseed and mustard crop in country is 1304 kg $ha^{-1}$. In the world's, India is fourth leading edible oil economy after the U.S.A, China and Brazil. It also contributes almost 6% of world vegetable oil production, 14% of the total vegetable oil imports in international market. On average the total market size of the Indian oilseed sector is about Rs. 600 billion (US$13.4 billion). In the framework of national agricultural system, mustard oilseed occupy 13% of the total gross cropped area in country and 3% to the gross national products (GDP) and 10% value among all agricultural products. Rapeseed and mustard crop has to be growing in different agro-climatic conditions which varying from north-eastern hills or north-western hills region to the south plateau region under irrigated or rainfed condition under timely or late sown situation and sole or mixed cropping. Phosphorus is necessary for Maintain and transmission of energy, transfer of genetic characteristics and beneficial for root development, vigorous growth, better yield and quality and nodule formation in legume crops. Phosphorus fixation is the major problems in productivity of crops concerning not only its actual deficiency in soil but also its availability to crop plants. Approximately 15-20% of applied fertilizer phosphorus is utilized by the crops and rest of the gets fixed in the soil. For enhancing availability and reducing the fixation of phosphorus, integrated phosphorus management (IPM) is the only viable strategy. In order to bring the soil well supplied with all essential plant nutrients and also to maintain good soil health it is necessary to use organic source like biofertilizers as PSB along with inorganic fertilizers. It not only enhances the phosphorus availability to crop plants, but reduce fixation, release the fixed form of phosphorus and improves the soil fertility. The experiment was, therefore conducted to study the effect of integrated phosphorus management on productivity of mustard, quality, nutrient uptake and fertility status. Application of Sulphur was reported to increase yield attributes and yield of Indian mustard, which also has a significant effect on oil, fatty acid and glucosinolates content in mustard seed. The relative proportions of individual glucosinolates *viz.*, sinigrin, gluconapin and progoitrin are influenced by sulphur application. Consequently, the present study was based on the hypothesis that increasing irrigation and sulphur levels may enhance the yield attributes, yield, sulphur uptake and quality of mustard.

## 2. Materials and Methods

### 2.1 Experimental site and Location

The field experiment was conducted at research farm Rama University, Kanpur (U.P.) located in Indo-Gangetic plains of Central Uttar Pradesh. The farm is geographically located at 26′ 49″ N latitude and 80′ 27″ E longitude with an elevation of 126m above the mean sea level. University lies at a distance of 18 km from Kanpur Central Railway Station.

### 2.2 Climate and weather

Kanpur predominantly enjoys semi-arid and sub-tropical climate with extremely hot summer and cold winter. Minimum and maximum temperature both exhibit a gradual decrease starting from first week of October and reach their minimum during December and January. An increase in the temperature is recorded with effect from first week of February and peak value is noticed in 3rd week of May.

**Table 1:** Mean weekly meteorological data recorded during the experimental season *Rabi* (Oct 2022-March 2023)

| Standard week | Temperature | | R.H. | | Rainfall (mm) | WS | Pan eva. (mm) |
|---|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | | | |
| 40 | 31.00 | 22.80 | 90 | 71 | 62.60 | 4.10 | 2.80 |
| 41 | 29.30 | 21.10 | 94 | 88 | 159 | 4.30 | 2.70 |
| 42 | 31.70 | 18.70 | 84 | 49 | 00 | 2.00 | 2.60 |
| 43 | 31.40 | 16.00 | 88 | 42 | 00 | 2.40 | 2.60 |
| 44 | 31.30 | 15.30 | 91 | 50 | 00 | 1.60 | 2.50 |
| 45 | 29.90 | 16.30 | 94 | 53 | 00 | 1.40 | 2.40 |
| 46 | 27.90 | 12.90 | 81 | 39 | 00 | 3.30 | 2.40 |
| 47 | 27.00 | 9.90 | 87 | 37 | 00 | 2.30 | 2.40 |
| 48 | 26.80 | 10.30 | 92 | 45 | 00 | 1.20 | 2.20 |
| 49 | 24.70 | 9.70 | 91 | 47 | 00 | 2.60 | 2.20 |
| 50 | 25.30 | 8.00 | 87 | 42 | 00 | 3.80 | 2.30 |
| 51 | 23.30 | 7.90 | 95 | 55 | 00 | 1.80 | 2.30 |
| 52 | 20.90 | 7.50 | 92 | 57 | 00 | 3.90 | 2.20 |
| 1 | 13.90 | 5.40 | 95 | 69 | 00 | 2.80 | 1.80 |
| 2 | 17.80 | 6.30 | 95 | 68 | 00 | 3.00 | 1.50 |
| 3 | 20.40 | 7.40 | 93 | 46 | 00 | 1.30 | 3.30 |
| 4 | 22.30 | 10.80 | 92 | 71 | 00 | 4.10 | 1.20 |
| 5 | 22.70 | 9.70 | 91 | 59 | 00 | 5.90 | 1.40 |
| 6 | 28.10 | 10.90 | 90 | 51 | 00 | 4.20 | 1.50 |
| 7 | 26.30 | 11.10 | 82 | 50 | 00 | 5.80 | 1.90 |
| 8 | 31.00 | 11.80 | 92 | 47 | 00 | 2.40 | 2.00 |
| 9 | 31.20 | 14.40 | 90 | 55 | 00 | 3.20 | 2.20 |
| 10 | 30.40 | 15.10 | 87 | 54 | 00 | 4.80 | 2.20 |
| 11 | 30.30 | 15.80 | 90 | 60 | 00 | 3.40 | 2.40 |
| 12 | 29.10 | 15.70 | 93 | 67 | 00 | 4.50 | 2.50 |
| 13 | 32.20 | 16.70 | 82 | 43 | 00 | 4.60 | 2.90 |

### 2.3 Soil of the experiment field

To determine various physico-chemical properties of soil sampling was done for a depth of 0-15 cm from 10 places before sowing of mustard crop in the experimental field.

**Table 2:** Physico-chemical properties of the experimental field.

| S. No. | Characteristics | Values | Method of analysis |
|---|---|---|---|
| (A) | | Physical characteristics | |
| | Particle size | % | |
| 1 | Sand | 54.40 | Hydrometer method (Bouyoucos, 1962) [22] |
| 2 | Silt | 25.60 | |
| 3 | Clay | 20 | |
| 1 | Bulk density (g cc-1) | 1.46 | Core method (Black, 1965) [18] |
| (B) | | Chemical characteristics | |
| 1 | pH | 7.7 | Glass electrode pH meter (Jackson, 1962) [19] |
| 2 | EC (dS $m^{-1}$ at 25 °C) | 0.34 | Solubridge (Jackson, 1962) [19] |
| 3 | Organic Carbon (%) | 0.48 | Rapid titration method(Walkley and Black'smethod, 1965) [18] |
| 4 | Available N (kg $ha^{-1}$) | 185.8 | Alkaline potassium permanganate method (Subbaiah and Asija, 1956) |
| 5 | Available P (kg $ha^{-1}$) | 16.7 | 0.5 M $NaHCO_3$ extractable (Olsen *et al.*, 1954) [20] |
| 6 | Available K (kg $ha^{-1}$) | 256.8 | 1N neutral ammonium acetate extractable (Muhr *et al*., 1973) [21] |
| 7 | Available S (mg $kg^{-1}$) | 14.3 | Turbidimetric method (Chesnin and Yien, 1959) |

The samples collected were mixed homogenously and a composite sample was drawn for analyzing various physico-chemical properties. The values obtained are given in Table: 2. The soil of experimental site was sandy loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus and potassium and slightly alkaline in reaction.

### 2.4 Cropping history of the experimental field

Cropping history of the experimental field for the last three years was carefully examined before initiating the present investigation and has been summarized in Table: 3. Since, several years, rice-Chickpea and maize-wheat cropping system has been practiced in the experimental field. Rice crop was grown during *kharif* season before experimental crop of mustard. This study was done in order to know the nature of crop grown on particular piece of land where the experiment was conducted and may be helpful in the interpretation and discussion of results.

**Table 3:** Cropping history of the experimental field

| Year | Crop | |
|---|---|---|
| | ***Kharif*** | ***Rabi*** |
| 2020-21 | Rice | Chickpea |
| 2021-22 | Maize | Wheat |
| 2022-23 | Rice | Experimental crop (Mustard) |

**2.5 Experimental detail:** Experimental design-RBD**,** Total no of treatments-7, No of replications-3, Total no. of plots-21, Gross plot size- 5 m x 4 m**,** Main irrigation channel = 1 m**,** Plot border = 0.5 m, Spacing 45 x 15 cm, RDF of NPK = 120: 60: 40 kg $ha^{-1,}$ Variety- Varuna.

### 2.5.1 Features of variety used

Varuna variety is recommended for cultivation in all over India. It is high yielding variety with seed size of 5.0-6.5g. Its average yield is 20-22q/ha. It matures in 135-140 days and contains 43.0% oil content

### 2.5.2 Treatments

Treatments were formulated as to ensure the possible and feasible solutions to the issues being realized by the farmers particularly, oilseed growers. The observations were decided to have required information for arriving at valid inferences. The experiment comprised of seven treatment combinations with three replications. These are presented here: $T_1$ = 100% RDF, $T_2$ = 75% RDF + 25 kg Sulphur $ha^{-1}$, $T_3$ = 75% RDF +PSB, $T_4$ = 75% RDF+ 25 kg Sulphur $ha^{-1}$ + PSB, $T_5$ = 100% RDF + 25 kg Sulphur $ha^{-1}$, $T_6$ = 100% RDF + PSB, $T_7$ = 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB

### 2.6 Details of Cultural Practices

Date wise cultural operations carried out in the experimental field are presented in table 4:

**Table 4:** Schedule of cultural operations carried out in the experiment field

| S. No. | Particular | Date | Implement/method used |
|---|---|---|---|
| 1. | Ploughing | 16.10.2022 | Tractor drawn disc plough |
| 2. | Harrowing | 16.10.2022 | Tractor drawn harrow |
| 3. | Levelling | 16.10.2022 | Tractor drawn leveller |
| 4. | Sowing | 17.10.2022 | Behind desi plough |
| 5. | Layout | 17.10.2022 | Manually |
| 6. | Basal application of fertilizer and FYM | 17.10.2022 | Manually |
| 7. | Topdressing (Urea) | 16.11.2022 | Manually |
| 8. | Irrigation | 15.11.2022<br>29.12.2022<br>28.01.2023 | Electric tube well |
| 9. | Thinning | 15.11.2022 | Manually |
| 10. | Weeding | 21.11.2022 | Manually |
| 11. | Foliar spray of Endosulfan 35 EC @ 1.5 l/ha to control mustard aphid | 25.01.2023 | By sprayer |
| 12. | Harvesting | 05.03.2023 | Manually by sickle |
| 13. | Threshing & Winnowing | 16.03.2023 | Manually |

**2.7 Biometric Observations**
To see the impact of treatments on the growth, yield attributing characters and yield of cultivar following observations were recorded and computed.

**2.8 Plant population**
The initial plant population per square meter was recorded after thinning (mustard) and final plant population per square meter was counted before harvesting or at maturity stage. For this purpose, one meter row at three places in each plot was ear marked after thinning. In marked places, plants were counted for both initial and final population. The total sum of plant number of three places was divided by 3 to get number of plants/square meter which was expressed per hectare.

**2.9 Plant height (cm)**
The height of the mustard plant was measured from the base to the top of the plant after 30, 60 and 90 days of sowing and at final harvesting, with the help of meter scale. The mean of plant height was worked out on the basis of total height of five randomly selected plants in each plot which was divided by the number of plants.

**2.10 Number of branches per plant**
Five plants from each plot were randomly selected and total numbers of primary and secondary branches were counted and mean of branches per plant were computed.

**2.11 Plant dry matter accumulation (g/plant)**
Five plants were randomly uprooted from observation row without damaging the root from each plot at 30, 60, 90 DAS and at harvest. The samples were air dried and then kept in oven for 24 hours at $70^0$ C, their dry weight was determined and the average dry weight per plant was calculated.

**2.12 Yield attributes and Yield**
**2.12.1 Number of siliquae/plants**
The Number of siliquae from five randomly selected plants was counted and reported on average basis.

**2.12.2 Length of siliqua (cm)**
Length of 10 randomly selected siliqua from main shoot, primary and secondary branches were measured and average reported as length of siliqua in cm.

**2.12.3 Number of seeds/siliquae**
The seeds from five randomly selected siliquae per plant were separated, counted and reported on average basis.

**2.13 Test weight (g)**
1000 seeds were randomly selected, counted from sample and weight was recorded in grams.

**2.14 Seed yield (q/ha)**
From the individual plot net plot area was harvested air dried and produce was threshed and cleaned. The final weight was recorded in kg/plot and converted seed yield into q/ha.

**2.15 Biological yield (q/ha)**
After harvesting, each net plot biomass was bundled and weighted before threshing. The weight, thus recorded was converted into (q/ha), as biological yield

**2.16 Stover yield (q/ha)**
Stover yield of mustard is calculated with subtraction of seed yield from biological yield and reported in (q/ha).

**2.17 Harvest Index (HI)**
Harvest index was calculated with the help of formula as suggested by Singh and Stockopf (1971):

HI = Economic Yield (Kg/ha) / Biological yield (Kg/ha) x 100

**2.18 Oil Content and Yield**
The seed samples were oven dried at 70 $^0$C till constant weight. The oil content was determined with the help of Soxhlet's extraction method (A.O.A.C 1970). The oil content was expressed in per cent. Oil yield was calculated by multiplying seed yield and oil content in the seeds:
Oil yield (kg $ha^{-1}$) = Oil% x Mustard yield (kg $ha^{-1}$) / 100

**2.19 Protein Content and yield**
The seed samples collected at harvest were used for estimation of total nitrogen content. Total nitrogen was determined using the modified micro Kjeldahl method (A.O.A.C. 1970). The% crude protein was calculated by multiplying% nitrogen with a constant factor of 6.25. Protein yield was calculated by multiplying the seed yield and protein content in seed.

**2.20 Economic Analysis**
**2.20.1 Cost of cultivation**
Cost of cultivation of mustard crop was calculated including treatment cost on the basis of local market price of different inputs used in cultivation.

**2.20.2 Gross return**
The gross income was calculated by multiplying the grain and by-product yield of each treatment with their minimum support price declared by the central government/ prevailing market prices.

**2.20.3 Net return**
Net monetary return was worked out for both the season separately by subtracting treatment wise total cost of cultivation from their gross monetary return.

**2.20.4 Benefit: Cost ratio (B: C)**
B: C was computed using the formula as given here below:
B:C = Gross monitory return (Rs./ha) / Total cost of cultivation (Rs./ha)

**2.21 Statistical analysis**
The SPSS technique was used for the analysis of variance to define the statistical significance of treatment effects. The significance of treatment effects was judged at 5% probability level. Further, 'F' test and significance of difference between treatments was examined by critical difference (CD) as described by Gomez and Gomez (1984) [23].

**Table 5:** Layout for Analysis of Variance (ANOVA)

| Source of variation | d.f. | S.S. | M.S.S. | F-cal. | F-tab.at 5% |
|---|---|---|---|---|---|
| Rplication | 2 | SSr | MSSr | | |
| Treatmnts | 6 | SSt | MSSt | F-cal | |
| Error | 12 | | | | |
| Total | 20 | | | | |

### 2.21.1 Standard error of mean

Standard error of mean was calculated as follows:
Standard error of mean (S.Em±) = $\sqrt{EMSS/r}$ Where;
S.Em ± = Standard error of mean EMSS = Error mean sum of square
r = Number of replications on which the observation is based.

### 2.21.2 Critical Difference

The critical difference at 5% level of significance was estimated as under:

C. D. = S.Em (±) ×√2 × t (at error degree of freedom)

## 3. Result and Discussion

The data collected during the course of investigation have been statistically analyzed and presented in tables. In terms of growth, yield attributing characters and seed yield as influenced by different nutrient combinations. An attempt has been made to evaluate and explain the salient findings recorded in the present investigation with a view to find out the "cause" and "effect" relationships as far as possible and to trace out the information of practical value. For the ease of discussion, the effect of treatments on growth and yield are described below:

### 3.1 Growth parameter

### 3.1.1 Plant population (plants m$^{-2}$)

The data related to plant population recorded at initial and harvest stage of crops are presented in (Table-6). The plant population differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum plant population 28.14 and 19.53 at initial and harvest stage followed by 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB. The significantly lowest population 24.39 and 16.20 was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher plant population than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment.

**Table 6:** Effect of Phosphorus Solubilizing Bacteria & Sulphur on plant population of mustard

| S. N. | Treatments | Initial plant population m-2 | Final plant population m-2 |
|---|---|---|---|
| 1. | 100% RDF | 24.69 | 17.23 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 24.39 | 16.20 |
| 3. | 75% RDF +PSB | 25.38 | 17.50 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 27.69 | 19.23 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 26.09 | 17.93 |
| 6. | 100% RDF + PSB | 26.66 | 18.86 |
| 7. | 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB | 28.14 | 19.53 |
| | SE(m)± | 0.70 | 0.48 |
| | CD at 5% | 2.18 | 1.50 |

### 3.1.2 Plant height (cm)

The data related to plant height recorded at 30, 60, 90 DAS and at harvest stage of crops are presented in (Table-7). The plant height differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum plant height 17.13, 120.18, 123.12 and 142.23 cm at 30, 60, 90 DAS and at harvest stage followed by 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB. The significantly lowest height 13.56, 109.24, 127.65 and 136.38 cm was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher plant height than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The result of the present study indicated that growth parameters of plant such as plant height, number of branches per plant of mustard crop (Table: 7 and 8) were significantly influenced by PSB and sulphur. Among the all treatments, application of 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB recorded maximum plant height, number of branches per plant was at par 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. The reason for higher values of growth had comparatively more nutrient availability and absorption than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. 75% RDF + 25 kg Sulphur ha$^{-1}$ plot produced significantly lower plant height, number of branches per plant and dry matter accumulation of mustard. This result confirms the finding of Ray *et al.*, (2015) [11] and Solanki *et al.*, (2015) [15].

**Table 7:** Effect of Phosphorus Solubilizing Bacteria & Sulphur on plant height of mustard

| S. N. | Treatments | Plant height(cm) | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | at Harvest |
| 1. | 100% RDF | 14.13 | 111.12 | 128.16 | 137.25 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 13.56 | 109.24 | 127.65 | 136.83 |
| 3. | 75% RDF +PSB | 14.83 | 115.14 | 129.45 | 138.63 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 16.80 | 118.28 | 131.79 | 141.33 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 15.84 | 115.68 | 130.53 | 139.47 |
| 6. | 100% RDF + PSB | 16.26 | 116.23 | 131.13 | 140.73 |
| 7. | 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB | 17.13 | 120.18 | 132.12 | 142.23 |
| | SE(m)± | 0.41 | 3.09 | 3.50 | 3.75 |
| | CD at 5% | 1.28 | 8.96 | 9.98 | 10.65 |

### 3.1.3 Number of primary and secondary branches per plant

The data related to primary and secondary branches per plant recorded at 60, 90 DAS and at harvest stage of crops are presented in (Table- 8). The plant height differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum primary branches per plant 14.25, 17.28 and 22.56 and secondary branches per plant 20.55, 24.12 and 25.23 at 60, 90 DAS and at harvest stage followed by 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant lowest primary branches 6.96, 9.09 and 16.05 and secondary branches 12.51, 18.75 and 18.90 per plant were observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher primary and secondary branches per plant than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Vyas *et al.*, (2003) [17] reported that the application of biofertilizer (Azotobacter + PSB) significantly increased the plant height, branch number, pod number and weight, seed and dry matter plant-1. The effect of Azotobacter among the biofertilizers used by more prominent, although the PSB was significantly increased these parameters.

**Table 8:** Effect of PSB and Sulphur on number of primary and secondary branches of mustard

| S. N. | Treatments | No. of primary branches/plant | | | No. of secondary branches/plant | | |
|---|---|---|---|---|---|---|---|
| | | 60 DAS | 90 DAS | at harvest | 60 DAS | 90 DAS | at harvest |
| 1. | 100% RDF | 7.86 | 9.60 | 17.37 | 14.34 | 19.44 | 19.05 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 6.96 | 9.09 | 16.05 | 12.51 | 18.75 | 18.90 |
| 3. | 75% RDF +PSB | 9.42 | 10.47 | 18.06 | 15.24 | 20.61 | 20.10 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 13.98 | 17.04 | 21.78 | 19.56 | 23.52 | 24.78 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 10.95 | 14.37 | 19.23 | 17.85 | 21.12 | 21.30 |
| 6. | 100% RDF + PSB | 12.46 | 16.44 | 20.55 | 18.54 | 22.74 | 23.67 |
| 7. | 100% RDF +25 kg Sulphur ha$^{-1}$ + PSB | 14.25 | 17.28 | 22.56 | 20.55 | 24.12 | 25.23 |
| | SE(m)± | 0.29 | 0.35 | 0.51 | 0.44 | 0.57 | 0.58 |
| | CD at 5% | 0.90 | 1.11 | 1.60 | 1.39 | 1.78 | 1.81 |

### 3.1.4 Fresh weight (gm) per plant
The data related to Fresh weight (gm) per plant recorded at 60 and 110 DAS of crops are presented in (Table 9). The Fresh weight (gm) per plant differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded highest Fresh and dry weight (gm) per plant 94.05, 83.10 and 19.06, 21.15 at 60 and 110 DAS, respectively followed by 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant lowest Fresh and dry weight (gm) per plant respectively 73.08, 55.35 and 12.33, 12.15 at 60 and 110 DAS was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Fresh and dry weight (gm) per plant than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment.

**Table 9:** Effect of PSB and Sulphur on fresh and dry weight per plant of mustard

| S.N. | Treatments | Fresh weight (g)/plant | | Dry weight (g)/plant | |
|---|---|---|---|---|---|
| | | 60 DAS | 110 DAS | 60 DAS | 110 DAS |
| 1. | 100% RDF | 75.63 | 61.65 | 13.53 | 14.13 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 73.08 | 55.35 | 12.33 | 12.15 |
| 3. | 75% RDF +PSB | 78.33 | 65.40 | 15.12 | 16.26 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 90.18 | 80.16 | 18.09 | 20.07 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 84.15 | 70.14 | 16.56 | 18.18 |
| 6. | 100% RDF + PSB | 88.11 | 78.33 | 17.43 | 17.97 |
| 7. | 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB | 94.05 | 83.10 | 19.06 | 21.15 |
| | SE(m)± | 2.21 | 1.86 | 0.42 | 0.45 |
| | CD at 5% | 6.89 | 5.82 | 1.32 | 1.42 |

## 3.2 Yield attributes
### 3.2.1 Days to 50% flowering
The data related to Days to 50% flowering recorded of crops are presented in (Table- 10). The Days to 50% flowering differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded Days to 50% flowering 49.50 followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant lowest Days to 50% flowering 44.16 was observed in 75% RDF + PSB treatment. The other treatments produced significantly higher Days to 50% flowering than 75% RDF + PSB treatment.

### 3.2.2 Number silique per plant
The data related to Number silique per plant recorded at harvesting time of crops are presented in (Table- 10). The Number silique per plant differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded highest Number silique per plant 316.98 at the time of harvesting followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant lowest Number silique per plant 262.65 was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Number silique per plant than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Sharma *et al.*, (2016) [12] reported that an application of 100% RDF of NPK in combination with FYM, Azotobacter and sulphur recorded a higher number of siliquae plant-1, number of seeds siliquae -1, length of siliqua (cm) and 1000-grain weight (g), seed yield, nutrient content and nutrient uptake and oil content and the minimum was noted with control.

### 3.2.3 Number of Seed per silique
The data related to Number of Seed per silique recorded at harvesting time of crops are presented in (Table-10). The Number of Seed per silique differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum Number of Seed per silique 17.10 at the time of harvesting followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Number of Seed per silique 13.44 was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Number of Seed per silique than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Jat *et al.*, (2013) [5] result revealed that the significantly increased the number of siliquae plant-1, number of seeds siliquae-1, test weight, seed yield, stover yield, oil content and oil yield in mustard as compared to control

### 3.2.4 Length of silique (cm)
The data related to Length of silique (cm) recorded at harvesting time of crops are presented in (Table-10). The Length of silique (cm) differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum Length of silique 6.90 cm at the time of harvesting

followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Length of silique 4.80 cm was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Length of silique (cm) than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Yield attributes *viz*. number of siliques per plant, number of seed per silique, Silique length (cm), number of seed per silique and test weight (g) (Table 10) were significantly influenced PSB and sulphur treatments. All the treatments significantly influenced the yield attributes as compared to control. Critical appraisal of data revealed that application of 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB recorded higher number of numbers of silique per plant, number of seed per silique, Silique length (cm), number of seed per silique and test weight (g) was at par the 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. The reason for higher values of yield attributes had comparatively more nutrient availability and absorption than other treatments which resulted in better crop growth and ultimately more dry matter accumulation. Control plot produced significantly lower number of silique per plant, number of seed per silique, Silique length (cm), number of seed per silique and test weight (Singh *et al.*, 2016; Rakesh and Ganesh 2016) [14, 10].

### 3.2.5 Test weight (g)

The data related to Test weight (g) recorded after the harvesting of crop are presented in (Table 10). The Test weight (g) differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum Test weight 5.91 g after the harvesting of crop followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Test weight 4.47 g was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Test weight of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Gudadhe *et al.*, (2005) [4] revealed that seed inoculation with Azotobacter and PSB along with 100% RDF (40:20:00 NPK ha$^{-1}$) significantly increased plant height, number of branches, dry matter accumulation and leaf area plant-1 number of siliquae plant-1, number of seed siliqua-1 and test weight.

**Table 10:** Effect of PSB and Sulphur on yield attributes of mustard

| S. N. | Treatments | Days to 50% flowering | No. of Silique plant-1 | No. of Seed silique-1 | Length of silique (cm) | Test weight (g) |
|---|---|---|---|---|---|---|
| 1. | 100% RDF | 47.25 | 267.43 | 13.50 | 5.31 | 4.53 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 47.70 | 262.65 | 13.44 | 4.80 | 4.47 |
| 3. | 75% RDF +PSB | 44.16 | 273.56 | 14.22 | 5.85 | 4.71 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 48.02 | 300.02 | 16.95 | 6.84 | 5.49 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 47.04 | 279.68 | 15.15 | 6.33 | 4.92 |
| 6. | 100% RDF + PSB | 47.94 | 285.03 | 16.80 | 6.60 | 5.25 |
| 7. | 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB | 49.50 | 316.98 | 17.10 | 6.90 | 5.91 |
| 8. | SE(m)± | 1.26 | 7.68 | 0.40 | 0.16 | 0.13 |
| 9. | CD at 5% | 3.61 | NS | 1.27 | 0.50 | 0.41 |

## 3.3 Yield

### 3.3.1 Biological yield q ha$^{-1}$

The data related to biological yield q ha$^{-1}$ recorded after the harvesting of crop are presented in (Table- 11). The biological yield q ha$^{-1}$ differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum biological yield 80.26 q ha$^{-1}$ after the harvesting of crop followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum biological yield 76.93 q ha$^{-1}$ was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher biological yield q ha$^{-1}$ of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Nagdive *et al.*, (2007) [9] observed that application 75 per cent RDF + FYM @ 5 t ha-1 + Azotobacter + PSB showed highest yield contributing characters and seed yield of mustard over other treatment.

### 3.3.2 Stover yield q ha$^{-1}$

The data related to Stover yield q ha$^{-1}$ recorded after the harvesting of crop are presented in (Table-11). The Stover yield q ha$^{-1}$ differed significantly due to different treatments. It was significantly noticed that RDF was most effective treatment recorded maximum Stover yield 57.93 q ha$^{-1}$ after the harvesting of crop followed by 75% RDF + 25 kg Sulphur ha$^{-1}$. Under the experiment significant minimum Stover yield q ha$^{-1}$ 54.89 q ha$^{-1}$ was observed in 75% RDF + PSB treatment. The other treatments produced significantly higher Stover yield q ha$^{-1}$ of crop than 75% RDF + PSB treatment. Seed and stover yield were significantly influenced by different treatments. An appraisal of data revealed that the application of 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB recorded higher seed and stover yield and statistically at par with application of 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. The significantly lower yield was recorded in 75% RDF + 25 kg Sulphur ha$^{-1}$ plot which was attributed due to poor yield attributing characters. These results were find out by Kumar *et al.*, (2019) [7] and Potdar *et al.* (2020) [24].

### 3.3.3 Grain yield q ha$^{-1}$

The data related to Grain yield q ha$^{-1}$ recorded after the harvesting of crop are presented in (Table-11). The Grain yield q ha$^{-1}$ differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was most effective treatment recorded maximum Grain yield 23.40 q ha$^{-1}$ after the harvesting of crop followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Grain yield 19.35 q ha$^{-1}$ was observed in 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Grain yield q ha$^{-1}$ of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. Mehta (2001) [8] revealed that application of 30 kg N + 15 kg P2O5 ha$^{-1}$ and (Azotobacter + PSB) significantly increased seed and stover yield (6.10 and 16.33 q ha$^{-1}$) of taramira.

### 3.3.4 Harvest index (%)
The data related to Harvest index recorded after the harvesting of crop are presented in (Table 11). The Harvest index differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum Harvest index 29.30 after the harvesting of crop followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum Harvest index 25.15 was observed in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher Harvest index of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. Verma and Dawson (2018) revealed that the maximum no. of siliquae plant-1 (144.86), no. of seeds siliqua-1 (41.60), test weight (3.18 g), seed yield (1.74 t $ha^{-1}$), harvest index (41.90%) and oil content (44.21%) under sulphur 30 kg ha -1.

### 3.3.5 Oil yield q $ha^{-1}$
The data related to Oil yield q $ha^{-1}$ recorded after the harvesting of crop are presented in (Table 11). The Oil yield q $ha^{-1}$ differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum Oil yield 10.22 q $ha^{-1}$ in grain after the harvesting of crop followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum Oil yield 7.50 q $ha^{-1}$ in grain was found in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher Oil yield q $ha^{-1}$ of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. Jat *et al.*, (2013) [5] result revealed that the significantly increased the number of siliquae plant-1, number of seeds siliquae-1, test weight, seed yield, stover yield, oil content and oil yield in mustard as compared to control

**Table 11:** Effect of Phosphorus Solubilizing Bacteria and Sulphur on yield of mustard

| S.N. | Treatments | Biological yield q $ha^{-1}$ | Stover yield q $ha^{-1}$ | Grain yield q $ha^{-1}$ | Harvest index (%) | Oil yield q $ha^{-1}$ |
|---|---|---|---|---|---|---|
| 1. | 100% RDF | 77.76 | 57.93 | 19.83 | 25.50 | 7.91 |
| 2. | 75% RDF + 25 kg Sulphur $ha^{-1}$ | 76.67 | 57.58 | 19.35 | 25.15 | 7.50 |
| 3. | 75% RDF +PSB | 75.35 | 54.89 | 20.46 | 27.15 | 8.33 |
| 4. | 75% RDF+ 25 kg Sulphur $ha^{-1}$ + PSB | 79.86 | 57.16 | 23.10 | 28.78 | 10.01 |
| 5. | 100% RDF + 25 kg Sulphur $ha^{-1}$ | 76.93 | 55.34 | 21.33 | 27.82 | 8.87 |
| 6. | 100% RDF + PSB | 79.80 | 57.15 | 22.65 | 28.38 | 9.62 |
| 7. | 100% RDF +25 kg Sulphur $ha^{-1}$ + PSB | 80.26 | 56.46 | 23.40 | 29.30 | 10.22 |
| | SE(m)± | 2.09 | 1.52 | 0.57 | 0.73 | 0.23 |
| | CD at 5% | 5.93 | 4.57 | 1.78 | 2.28 | 0.73 |

### 3.4 Grain quality
### 3.4.1 Oil% in grain
The data related to Oil% in grain recorded after analysis of grain are presented in (Table- 12). The Oil% in grain differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum Oil 43.71% in grain after the harvesting of crop followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum Oil 38.76% in grain was found in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher Oil% in grain of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment.

### 3.4.2 N content in grain
The data related to N content in grain recorded after the analysis of grain are presented in (Table-12). The N content in grain differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum N content 3.57% in grain after the analysis of grain followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum N 3.12% in grain was found in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher N content in grain of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment.

### 3.4.3 P content in grain
The data related to P content in grain recorded after the analysis of grain are presented in (Table-12). The P content in grain differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum P content 0.76% in grain after the analysis of grain followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum P content 0.59% in grain was found in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher P content in grain of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. Dubey *et al.*, (1997) [3] reported that PSB inoculation was found effective in increasing 42.89% of P content of mustard plant over control. Application of 30 kg P2O5 $ha^{-1}$ as SSP with inoculation was effective in increasing more than threefold increase in P content as well as P uptake in all the over control.

### 3.4.4 K content in grain
The data related to K content in grain recorded after the analysis of grain are presented in (Table-12). The K content in grain differed significantly due to different treatments. It was significantly noticed that 100% RDF + 25 kg Sulphur $ha^{-1}$ + PSB was most effective treatment recorded maximum K content 1.54% in grain after the analysis of grain followed by 75% RDF + 25 kg Sulphur $ha^{-1}$ + PSB. Under the experiment significant minimum K content 1.37% in grain was found in 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. The other treatments produced significantly higher K content in grain of crop than 75% RDF + 25 kg Sulphur $ha^{-1}$ treatment. Chand (2001) [2] study the integrated nutrient management in mustard. The experiment consisted of 32 treatment combination comprising four levels of chemical fertilizers (0, 50, 75 and 100% RDF) two levels of FYM (0 and 10 t $ha^{-1}$) and four levels of biofertilizers (No biofertilizers, PSB, Azotobacter and PSB + Azotobacter). The results revealed that significant improvement in content and uptake of nutrients (N, P, K, and S) and micronutrients (Fe, Cu, Mn, and Zn) by plants with application of increasing levels of fertilizers, FYM and biofertilizers.

**Table 12:** Effect of PSB and Sulphur on quality of mustard grain

| S.N. | Treatments | Oil% in grain | N content in grain | P content in grain | K content in grain |
|---|---|---|---|---|---|
| 1. | 100% RDF | 39.91 | 3.24 | 0.62 | 1.42 |
| 2. | 75% RDF + 25 kg Sulphur ha$^{-1}$ | 38.76 | 3.12 | 0.59 | 1.37 |
| 3. | 75% RDF +PSB | 40.75 | 3.33 | 0.67 | 1.45 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 43.35 | 3.54 | 0.75 | 1.52 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 41.63 | 3.36 | 0.71 | 1.49 |
| 6. | 100% RDF + PSB | 42.51 | 3.51 | 0.72 | 1.50 |
| 7. | 100% RDF+25 kg Sulphur ha$^{-1}$ + PSB | 43.71 | 3.57 | 0.76 | 1.54 |
| | SE(m)± | 1.11 | 0.09 | 0.01 | 0.03 |
| | CD at 5% | 3.30 | 0.28 | 0.05 | 0.10 |

### 3.5 Economics 4.5

#### 3.5.1 Total cost of cultivation (Rs ha$^{-1}$)

The data related to Total cost of cultivation presented in (Table-13). It was significantly noticed that 100% RDF + PSB was recorded maximum Total cost of cultivation 35,944 Rs ha$^{-1}$ followed by 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Total cost of cultivation 33,040 Rs ha$^{-1}$ of 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher cost of cultivation of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment.

#### 3.5.2 Gross monitory return (Rs ha$^{-1}$)

The data related to Gross monitory return presented in (Table-13). It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was recorded maximum Gross monitory return 1,53,999 Rs ha$^{-1}$ followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Gross monitory return 1,14,094.50 Rs ha$^{-1}$ of 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Gross monitory return of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment.

#### 3.5.3 Net monitory return (Rs ha$^{-1}$)

The data related to Net monitory return presented in (Table-13). It was significantly noticed that 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was recorded maximum Net monitory return 1,00,670 Rs ha$^{-1}$ followed by 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. Under the experiment significant minimum Net monitory return 81,054.50 Rs ha$^{-1}$ of 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment. The other treatments produced significantly higher Net monitory return of crop than 75% RDF + 25 kg Sulphur ha$^{-1}$ treatment.

#### 3.5.4 B:C Ratio

The data related to B:C Ratio presented in (Table 13). It was significantly noticed that 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB was recorded maximum B:C Ratio 2.97 followed by control. Under the experiment significant minimum B:C Ratio 2.38 of control treatment. The other treatments produced significantly higher B:C Ratio of crop than control treatment. The gross return obtained by yield of crop varied markedly due to different treatments, which ultimately influenced the net return and B:C ratio. The data on economics of various treatments revealed that the recorded the maximum net return (Rs 1,00670 ha$^{-1}$) with the treatment of 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB and B:C ratio (2.97) with the application of 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB. The lowest benefit cost ratio (2.38) was obtained with control treatment.

Kumar and Kumar (2011) [6] study the effect of different levels of sulphur (0, 20, 40 and 60 kg ha$^{-1}$) on yield and noticed that sulphur increased the no. of pods plant$^{-1}$ and no. of seeds pod-1 significantly over control. The maximum net return Rs 30940 ha$^{-1}$ was obtained with application of 20 kg S ha$^{-1}$. Vijayeswarudu *et al.*, (2021) [25] revealed that the growth parameters such as yield attributes *viz*., number of siliqua plant-1 (133.92), number of seeds siliquae-1 (33.80) and test weight (3.63 g) at harvest, significantly recorded in treatment $T_3$ with the application of PSB+45 kg S ha$^{-1}$. However seed yield (1.80 t ha$^{-1}$), stover yield (3.36 t ha$^{-1}$), gross returns (117000.00 Rs ha$^{-1}$), net returns (79573.58 Rs ha$^{-1}$) and B:C ratio (2.12) was significantly recorded in the treatment of T3 which is PSB+45 kg S ha$^{-1}$ among all treatments.

**Table 13:** Effect of PSB and Sulphur on Economics of mustard

| S. N. | Treatments | Total cost (Rs ha$^{-1}$) | Gross monitory return (Rs ha$^{-1}$) | Net monitory return (Rs ha$^{-1}$) | B:C Ratio |
|---|---|---|---|---|---|
| 1. | 100% RDF | 34,544 | 1,16,763 | 82,219 | 2.38 |
| 2. | 75% RDF + 25 kg Sulphur ha-1 | 33,040 | 1,14,094.5 | 81,054.5 | 2.45 |
| 3. | 75% RDF +PSB | 33,846 | 1,19,740.5 | 85,894.5 | 2.53 |
| 4. | 75% RDF+ 25 kg Sulphur ha$^{-1}$ + PSB | 33,840 | 1,34,469 | 1,00,629 | 2.97 |
| 5. | 100% RDF + 25 kg Sulphur ha$^{-1}$ | 34,529 | 1,24,549.5 | 90,020.5 | 2.60 |
| 6. | 100% RDF + PSB | 35,944 | 1,32,015 | 96,071 | 2.67 |
| 7. | 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB | 35,329 | 1,35,999 | 1,00,670 | 2.84 |

## 4. Conclusion

On the basis of foregoing discussion, it may be seen that application of 100% RDF + 25 kg Sulphur ha$^{-1}$ + PSB ($T_7$) inoculation to mustard crop produced at par yield of mustard to 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB and gave the best residual effect on soil. Thus, in order to get maximum net return from mustard, application of 75% RDF + 25 kg Sulphur ha$^{-1}$ + PSB seems to be the best treatment for sustainable production and maintain the physicochemical and chemical properties of soil.

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